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MOTION MODELS: THEIR USE IN THE TRANSFERENCE OF EXPERIENCE AND THE PRESENTATION OF COMPARATIVE RESULTS IN EDUCATIONAL METHODS

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This is the age of measurement. The motion model is a new device of measurement. It is for this reason that we are presenting the motion model to-day to this section of this Association, which stands for accurate measurement, and which believes that advancement must come through such measurement.

Your general subject for this meeting is listed as "The Scientific Study of Educational Problems." You are to be congratulated upon having chosen such a subject, and thus having shown your belief that advances in education, as in other fields of activity, depend upon the application of the scientific method to the solution of the various problems involved. The *art* of teaching need never lose its ancient respect and standing, but the *science* of teaching, which in no wise supplants or interferes with the art, enlists a new cooperation from all those engaged in like types of activity, and should arouse a new interest in educators themselves. Only where the scientific method is applied can one expect to find invention that is improvement, and progress that is continuous and permanent.

Now the continuous application of the scientific method demands three things:

1. Units of measurement.
2. Methods of measurement.
3. Devices by which measurement can be made, and can be made at a decreasing cost.

Many such units, methods and devices of measurement, as applied to education, already exist. There has been, however, in all fields where education is going on a lack of means by which behavior could be accurately recorded, and the records used as data for predicting behavior, and for outlining methods for attaining future desired results. Motion models supply this lack. They were derived in industrial experience, and were first applied in teaching in the industries, but their use is not limited to the industrial field, nor to teaching of manual operations.

The fact that this paper is presented here is indicative of new feeling that is growing up in all fields of activity, of the necessity of correlation. This realization of the importance of correlation is the outcome of many things. One is the tendency of this age to think in parts rather than in wholes, in elements rather than in grouped elements. In the olden times, both material things and human beings were invariably thought of as entities, wholes; but with closer thinking, and the awakening of the scientific spirit of analysis, measurement, standardization and synthesis, has come the realization that the fact that the thing or person as a whole is often far less important than the fact that the thing or person is a group, or community, or combination of parts. The material thing is analyzed into its elements. The human being is thought of as a group of working members. The old-time operation is thought of as a combination of acts. Now, finally, the motion itself is thought of as a cycle or combination of elements of motions.

With this intensive study of elements has come also a realization of the importance of likenesses between things. This emphasis on likenesses may be given as the second reason for the realization of the necessity of correlation. The old-time wise man wondered at the differences between things, and the scientist for years and decades followed the old-time wise man, and placed the emphasis in his classifications upon differencies. Our ordinary classifications of today are thus based: for example, classifications of the trades are based more or less indefinitely upon

a. Difference between the types of men who do the work.
b. Differences in the ability and general education of the worker.
c. Differences in the kinds of, or the value of, materials handled.
d. Differences in the surrounding conditions.

Similar emphasis on difference marks the division of the trades from the professions, a difference so insisted upon that any attempt to correlate the work of, say, a surgeon, typist and bricklayer, meets with instant and almost universal disapproval. Yet the trend in science to-day makes it more and more apparent that all have neglected emphasizing the likenesses to an astounding degree, and that a heavy price has been paid for this neglect.* The very idea of difference implies division. This has set up for years boundaries between experiences, professional experiences and teaching experiences, that it will require yeoman work to destroy.

Yet splendid work is to-day being done in correlation. In the field of education the work done has not only a scientifically derived theory to support it, but can also show practical and successful results. This work is acting as a stimulus and a guide to workers in other fields of activity. Much undoubtedly remains to be done in correlating various types of teaching and learning in the schools, but what has been done is an indication of what can and will be done, and there need be no fear of the ultimate results. Educators are also to be congratulated on the beginnings made in correlating teaching in the schools and colleges and in the industries, such, for example, as in the half-time work now being increasingly introduced throughout the country. However, this correlation has usually been imperfect in that, while the teacher of such "half-time" pupils consciously adapts the school work to fit the shop needs of the pupils, the shop teacher and school teacher have not generally, as yet, compared methods and

*See "Primer of Scientific Management," D. Van Nostrand Co., New York City.

attempted to make the pupils' learning experience a unified one. Shop teaching, or to put it in a general phrase, "transference of skill and experience in the industries," is at present such an indefinite thing that one can scarcely blame either side for this lack of correlation. In this country, and in the same locality, are existing side by side to-day methods of teaching as old as the time of the guilds and the most modern methods of teaching, with an indefinite and surprisingly large number of steps, or grades of teaching, in between. It would undoubtedly interest, and it might profit, educators to trace the history of teaching in the industries; but this meeting is not the place, nor is this the time, to present such a history. This, because the need for immediate correlation of teaching in the school and in the industry is so pressing and so great.

Never in the history of the world has there been such a need as there is to-day for economy in all lines, to compensate as far as possible for the enormous loss in human and material things caused by the great war. We have endeavored to bring out in various recent papers* the immensity of this loss, and to outline various methods by which it may be partially met. No body of thinkers realizes more clearly than do the educators just what this loss means, and none have proved more ready to do their part towards meeting it, as is testified by the noble work done by educators in all the warring countries in standing ready and glad to do their part in the "making-good process."

We are presenting, therefore, in this paper what we believe to be the most advanced type of teaching in the industries, as a contribution towards that correlation for which we all long. This method is the result of years of experience as learners and teachers in many lines of activity. It has the increasing support of psychologists and teachers as well as of managers. We offer it not only hoping that it may prove of service in your various lines of activity, but with the assurance that you will immediately test it in every way possible by your own data and experience, and

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*"Motion Study and Time Study Instruments of Precision," Vol. XI, 1915. "Transactions of the International Engineering Congress." "Motion Study for the Crippled Soldiers." "The Journal of the American Society of Mechanical Engineers," December, 1915. "Chronocyclegraph Motion Devices for Measuring Achievement," Second Pan-American Scientific Congress, December, 1915.

allow us to benefit by the results of the tests. We come with an equally hearty desire for cooperation, for this, in the final analysis, is the most satisfying incentive of all.

In order to make clear what this device, the motion model, is, and what the methods are in which it may be used, and by which it is used, it is necessary to trace, though only in outline, the history of its evolution.

The motion model is a wire representation of the path of a motion. It is the result of years of endeavor on our part to put a motion in such visible and tangible form that it may be visualized and measured with accuracy, and that the laws underlying

1. The behavior that caused and affected the motion,
2. The behavior that resulted from the motion,

may be scientifically determined. This desire to understand motions thoroughly has been a driving force with the writers ever since the start of motion study itself. The study of motions, of course, is not new. It must have existed, whether used consciously or not, ever since there was any activity at all; but what is now generally understood by the phrase "motion study" had its beginning in the year 1885. We quote here an earlier account, by one of the writers, of his first day at construction work. This will be of interest to this particular audience as not only outlining what occurred, but indicating to some extent the mental process that lay back of it. We quote:

"I started learning the work of the construction engineer on July 12, 1885, as I had been promised that a thorough mastering of at least one trade, and a general practical experience with many trades, would be followed by rapid promotion in my particular line of engineering. I was, accordingly, put to work between two specially selected, expert bricklayers, who were instructed that they were to teach me the trade as rapidly as possible. They gladly agreed to this. First one taught me, then the other, and, much to my surprise, they taught me entirely different methods. To make matters still more puzzling to me, I found that the methods that they taught me were not the methods that they themselves used. Now, I had the idea that, if I could learn one way thoroughly, I could be promoted in the shortest time possible to the higher position promised me. It seemed perfectly obvious that to learn two ways would take much longer than to learn one way, perhaps twice as long. Yet each man was an expert, whose methods were considered perfectly satisfactory, and each was turning out a large quantity of work excellent in quality. Hoping to discover which method taught me was the better, after a short time I quietly placed myself between two other bricklayers of my own selection. These were as willing to teach me as the first two had been, but I became more puzzled than ever when I found that their methods were different and that neither one taught me either of the methods shown me by my first two teachers. Naturally, the foreman soon sent me back from my own wanderings to my first location. All my friends, however, had one common rule for me, 'Keep at it on each brick until it is in true position.' I struggled on, trying to follow first one method and then another that was being taught me, and being constantly admonished by my first teacher, 'not to make so many motions.' Disgusted at my unsatisfactory results, I began watching this first teacher more closely, when he was working, and found that he used two entirely different sets of motions when doing his own work, both of these differing radically from the demonstration set that he used to teach me. That is, all three sets of motions were used to do identically the same type of work, the only difference being that Set One was used to teach the beginner, Set Two was used when working slowly, and Set Three was used when working rapidly. I looked at my second teacher. He also had three sets of motions. From that day I continued to observe as far and as fast as I could, and have found in practically every case that every worker has at least three distinct sets of motions for doing the same work.

"Naturally, as time went on, I came to ask my various teachers, 'What is the quickest way?' Each one had his own special 'kinks,' or short cuts, such as putting two bricks together in the air and then placing them together in the middle of the wall. Of course, I had to try out each of them, but soon found the great difficulty of achieving the first quality and, at the same time, using high speed motions while working.

"My observations involved certain fundamental questions:

"1. Why did the teacher use different motions when teaching than when himself working?

"2. Why did the teacher use different motions when working slowly than when working rapidly?

"3. Which of the three methods used was the right method?

"4. Why did each teacher observed have his own special set of short cuts, or 'kinks'?

"5. What was really the best method of doing the work?

"6. Was the insistence on quality first and right methods second advisable?

"7. At what speed should the beginner be taught to do his work?"

Through all these years we have been trying to find the reasons why the conditions that were so puzzling existed, and the answers to the questions here enumerated. Both reasons and answers depend upon a few simple and easily stated facts. We say "facts" advisedly, for the motion models have proved them to be such. We use the word with exultation, for, while we believed them to be facts for years, because the results justified the theories, we have often been ridiculed by students and investigators in all lines for so believing. Only since the motion models demonstrated the facts are they coming to be acknowledged as such, and are we receiving assistance in making them more generally useful.

The facts are as follows:

1. The motions are the elements to be considered in learning to perform an activity.

2. Right motions must be insisted upon from the beginner's first day at work.

3. Right motions do not lie in the consecutive acts of any one person performing the activity, unless he has been specially taught the standard method.

4. Fast motions are different from slow motions.

5. Standard speed of motions must be insisted upon from the learner's beginning on his first day, if least waste of learning is the first consideration.

6. Right motions at standard speed produce right quality.

7. The best learning process consists of producing right motions at the standard speed in accordance with the laws of habit formation.

We might here turn immediately to the motion model and show how it demonstrates these facts, but the demonstration will be clearer if the steps in the process of the derivation are carefully stated. We shall, therefore, return to the seven questions listed above, and state in each case our conclusions as to the answer.

1. The teacher used different motions when teaching than when working himself because he did not recognize his activity as consisting of motion elements. He attempted to demonstrate to the pupil that method that would obtain the desired quality of work product. He placed the emphasis on quality of output rather than on speed of learning.

2. The teacher used different motions when working slowly than when working rapidly because of the different muscle tension involved. When placing the emphasis upon speed, he was favorably affected by the variables of centrifugal force, inertia, momentum, combination of motions and play for position.* When there was no such emphasis on speed he was differently affected by these variables.

3. While none of the three methods of any individual worker was at all likely to be the standard method, the method used when working rapidly was most likely to approximate the standard.

4. Each teacher had his own short cuts in so far as he had consciously or unconsciously thought in motion economy. These differed because it was not customary to compare methods, because working conditions sometimes imply trade secrets, and because there was no adequate correlation between existing methods;—the eye being able to recognize the slow motions only.

5. The best method of doing the work did not at that time exist, because, due to lack of measuring methods and devices, it was not possible to record the elements, or motions, of all the different methods; to measure these, and to synthesize a standard method from the data.

*See "Motion Study," D. Van Nostrand Co., New York City.

6. The insistence on quality first and right methods second was entirely wrong, since it allowed of the formation of wrong habits of motions, the result of which is a lifelong detriment to the user. The proper insistence is upon right methods at standard speed first, and quality of work product second. It must always be understood that absolute accuracy of method and speed occur simultaneously only with the desired quality. That is to say, take care of the method and the speed, and the quality will quickly take care of itself.

7. The beginner should be taught to do his work immediately with motions of standard speed. Quality should be attended to, however, in every instance

a. By having the learner stop constructive work long enough to correct what he has done, or do it over again until it is of proper quality, care being taken not to confuse the doing with the correcting.

b. By having some one else correct the work as many times as is necessary, until it becomes of proper quality.

c. By having the learner work where the finest quality is not essential.

The determination as to which of these three methods for providing that the resulting product be of desired quality be used depends upon the type of work done and the type of learner.

It is probably needless to tell a gathering like this assembled here what a storm of adverse criticism the answers to these questions, embodying our beliefs, has caused in the engineering, and also in the educational world. In fact, this storm of criticism still rages to-day, and we expect many objections to the teaching process here involved from you at the close of this paper. We ask, however, at this point that you suspend judgment in this matter. Set aside all of your prejudices and even, perhaps, your experience, to put yourself into our attitude in working out what we have stated are the most efficient processes, and then at the conclusion strike the balance and assist us with your criticism.

You can see that all of our conclusions rest upon the possibility of examining and comparing motions and their results. The first necessity, then, was to obtain an accurate record of the motion. We used the fewest motions, shortest motions and least fatiguing motions possible. We wrote, and collected, descriptions of motions. We made diagrams of the surrounding conditions, even to the location of the worker's feet, at the time when efficient work was being done. We recorded the best we found by photography, at first with an ordinary camera, later with stereoscopic cameras. These gave us detailed records in three dimensions. We used the cinematograph to record the motions being made against a cross-sectioned background, floor and workbench. This enabled us to record and follow the motions more accurately. We then invented a special microchronometer for placing in the picture, when we could find none in the market that could give us fine enough intervals to record the relative times of different motions. This micromotion process, with its combination of the cinematograph, the special timing devices and the cross-sectioned screen, enabled us to obtain accurate and satisfactory records of methods used, except that it did not enable us to visualize clearly the path taken by the motions and the elements of the motions.* Our next step was to attach a miniature electric light to the hand of the worker; to photograph the worker, while performing the operation being studied, and thus to obtain the motion path under actual working conditions. Through the use of an interrupter in the light circuit we obtained the photography of time in a single exposure. Later, through a time controlled interrupter, we obtained photographs of exact even periods of elapsed time of any desired duration. Through the use of a special arrangement we obtained time spots that were arrowshaped that gave us the invention of the photography of direction. Through the use of the penetrating screen we obtained exact distance, and thus exact speed, of motions. Finally, through the use of the chronocyclegraph method, which is a combination of these various devices, we obtained a satisfactory record of a motion path, showing relative time, exact time, relative speed, exact speed, and direction of all motions in three dimensions. This chronocyclegraph now answers every requirement as a recording device, and also as a demonstrator of the correctness of our recommended practice, but it is not always a completely satisfactory device with which to demonstrate, simply because of the fact that the stereochrono-

*See "Bricklaying System," Myron C. Clark Company, Chicago, Ill.
See works of Muybridge, Marey, Amar.

cyclegraph is not tangible. While it is possible to throw the stereoscopic records upon the screen, it is not satisfactory to enable an entire audience to visualize a motion path simultaneously. We were forced to use individual, single or magazine stereoscopes. As a result, any group of learners, although provided with stereoscopes and with the same picture, or cyclegraph record, find it difficult to use or visualize the cyclegraph simultaneously. It is difficult to concentrate the group mind upon the individual subdivisions of the motion. The motion models overcome this difficulty, making the motion path actually tangible. They enable us to demonstrate to the group mind.

The chronocyclegraph is a perfect record. It is free from the errors of prejudice, carelessness, and all other personal elements. The motion model is the precise record made tangible, and transformed into a satisfactory teaching device. We must, however, establish the validity of our records before enumerating the advantages of our teaching devices. What does the chronocyclegraph show? We group the following in accordance with the seven facts stated before:

1. The chronocyclegraph shows that the sub-division of the motion cycle is the important element. The motion cycle can be accurately recorded, hence analyzed into elements that may be standardized and synthesized into a recorded method. The time taken to do the work cannot be used as a preliminary standard, the worker being allowed to use any set of motions that he desires. The elements of such a set not being scientifically determined, the user of the motions will either take longer than necessary to do the work, or become unnecessarily fatigued. In order to come within the time, he must finally arrive at what would at least be a habitual cycle of motions, many of which are inefficient. If any wrong habit of motions occurs there will be a serious loss later by reason of habit interference, with consequent unnecessary fatigue, and the likelihood of the time ever becoming standard will be greatly reduced. The quality of the output cannot be made the preliminary standard, since this would allow of unstandardized motions, with an ensuing decrease of speed, and would result in unstandardized times.

2. The chronocyclegraph shows plainly the effects of habit.

We have convincing illustrations of loss in efficiency due to the intrusion of old habits. They show that a discarded habit will return and obtrude itself when a new method is for some reason insisted upon, and the existing habit cycle is broken down in order that the new one may be formed. Say, the worker used originally habit A, and has come to use habit B. If he be taught cycle C, which differs from A and B, where he fails in C, he will be apt to introduce an element from A, not from B. The complication is evident. To profit by habit the laws of habit formation must be rigidly utilized.* These laws support the dictum, "Right motions first."

3. A comparison of the chronocyclegraph of the various workers, studied in connection with the quantity and quality of the output achieved and with the standard method finally derived, shows that the best method does not lie in the motion cycle, or in the consecutive motion cycles, of any one individual. The micromotion records are of enormous benefit here, in that they enable us, at any time and place, to review the methods used by each worker, and to compare them.

4. The chronocyclegraph of the same worker performing the same work at different rates of speed demonstrated absolutely that fast motions are different from slow motions. They do not follow the same path or orbit. Micromotion records are here again of enormous assistance. Through them we were enabled to observe the worker performing the work at practically any speed that we may desire to see him use, as determined by the number of pictures projected per second on the screen. Those of you who have made a study of motion picture films, their making and projecting, and who have analyzed trick films, where the people move far above, or below, the normal speed of real life, will at once realize the possibilities in motion analysis that lie here.

5. It having been shown that fast motions are different from slow motions, it becomes self-evident that, in accordance with the laws of habit formation, the learner must be taught the standard speed of motions from the first day. If he is not, he will not form properly the habit of using the forces that lie in his own body under his own control, of which he is usually at present unaware.

*See "The Psychology of Management," Sturgis and Walton Co., New York City.

It must not be understood that standard speed means always high speed. It does not. It means that rate of speed that will produce the desired results most efficiently. It must be remembered that there are a few motions that cannot be made at the standard speed at first by the beginner. In such cases the speed should be as near as possible that used by the expert.

6. The records of quantity and quality of output that are made simultaneously with the chronocyclegraph records demonstrate that right motions at the right speed produce the desired quality. This is, also, demonstrable through logic. The first thing to be standardized is the quality of the resulting product desired. The standard method is then made to be that method of performing the work that will produce this quality most efficiently. Through performing the standard method at the correct speed the standard quality does and must invariably result. During the learning process, of course, quality will seem to go by the board, but this is only during the period that the learner cannot succeed in performing the method described. The correlation between the methods and the quality is perfect. Therefore, the expected and desired result must come to pass.

7. The teaching must, therefore, consist of two things:

a. The right method must be presented at the standard speed. The right method, taken with the cinematograph at standard speed of motions, may be presented slowly by projecting fewer pictures per second on the screen, but in any case the motions must be made at the standard speeds when being photographed.

b. The right method must be followed during the determined length of time, with the proper rest intervals for overcoming fatigue, and always with sufficient incentive.

The learning process is the proper repetition of the desired method at the standard speed.

It remains but to show the relation of the motion model to the chronocyclegraph, the use of the motion model for teaching, and for comparing the results of various methods of teaching. The motion models are made by observing the chronocyclegraph through the stereoscope, and bending a wire until it coincides with the path of the motion observed. The chronocyclegraph is best made in combination with the penetrating screen, that enables the motion model maker to measure, and thus to transfer to his wire very small elements of the motion path. The motion model maker is provided with a cross-sectioned background against which he can hold his model during the construction period, to compare his results with the cyclegraph from which he is working. He is also provided with a cross-sectioned box in which he may place the model, for observation and analysis. As the original cyclegraph, by means of the penetrating screen method, may be inclosed in a box of as many sides as are desired, it is often possible to facilitate the making of the model by the use of a properly cross-sectioned box. This box is of wood painted black, with the cross-sectioning done in white. The motion model, upon its completion, is painted black. The spots upon the chronocyclegraph are represented by spots painted upon the model. These spots are made of white paint, shading gradually through gray to black, and when finished resemble very closely in shape the pointed spots seen upon the chronocyclegraph. The motion model, which has now become a chronocyclegraph motion model, may be fastened against a cross-sectioned background and photographed from exactly the same viewpoint from which the chronocyclegraph was taken. The photograph of the model and the chronocyclegraph record may then be compared. Unless they are exactly similar the motion model is not considered a complete success. In cases where the motion cycle recorded is complicated, it is of great assistance to take chronocyclegraph records from several different viewpoints, as such records assist in making the motion model more perfect. In some cases two or more viewpoints can be obtained by mirrors.

The motion model has all the uses of the chronocyclegraph as a recorder of standards. In addition it has its teaching uses. The first of these is as assistance in visualizing the motion path. The motion model makes it possible actually to see the path that the motion traverses. It makes it possible to see this path from all angles. This was not possible with the chronocyclegraph, for, even where many chronocyclegraphs were made, the sum total of them only represented viewing the motion from the specific number of angles. The motion model can be viewed from all directions, from above, from below, and from all sides. A further importance of this in the industries is seen in the effect of the motion model upon the invention and redesigning of machinery to conform to least wasteful motions. The necessary limitations of shop conditions, machine operations, etc., make it often impossible to obtain a chronocyclegraph from more than one direction. Here we have all such limitations for viewing the motion removed. The motion model thus immediately educates its user by enabling him to see something that he has never before seen.

The motion model also teaches its user to make more intelligent use of chronocyclegraphs and cyclegraphs. These take on a new meaning when one has actually seen and used their corresponding models. In point of fact, a constant use of the motion model is a great help in visualizing a motion path without a chronocyclegraph. Of course, such visualizing cannot compare with the chronocyclegraph record, though it is often sufficient as a stimulus to motion economy and to invention. The motion model is also of use in that it enables one to teach the path of the motion. It makes it tangible. It makes the learner realize the problem of transportation involved. This has the byproduct of impressing the user with the value of motions. It is extremely difficult to demonstrate to the average person the reality and value, and especially the money value, of an intangible thing. The motion model makes this value apparent and impressive. It makes tangible the fact that time is money, and that an unnecessary motion is money lost forever.

The motion model is of peculiar value to its maker. The process of observing chronocyclegraphs and then bending the wire accordingly is not only excellent training in accurate observation, but impresses the maker, as probably nothing else could, with the importance of motions. He comes to be extremely interested in the significance of every curve and bend and twist and change of direction. He comes to realize the importance of the slightest change from a straight line, or a smooth curve. The elements in the motion cycle become apparent. He learns to think in elementary motions.

There are at least two methods, then, by which the models may be used to transfer experience.

1. By having the learner make such models.
2. By having the learner use such models.

The sequence with which these two methods should be used would be determined by the thing being taught, by the learner, by the teacher, and by many other variables. If the object of the teaching is to transfer some definite experience, or skill, in the shortest possible amount of time, it is better to give the completed model to the learner at the outset, and allow him to make a model later when he has learned the standard method, and may be stimulated to invention. If the object is to teach the learner the importance of motions and their elements, it is better to allow him to make a motion model first and to use the model later.

There is also a great difference between the method by which the motion model is used to teach the expert and to teach the beginner. The expert uses the motion model for learning the existing motion path and the possible lines for improvement. He notes the indications of an efficient motion, its smoothness, its grace, its strong marks of habit, its indication of decision and of lack of fatigue. Nothing but a close study of an efficient motion, as compared with the various stages of inefficiency through which it passed, can make clear these various indications. The changes from awkwardness to grace, from indecision or hesitation to decision, from imperfect habit to perfect habit, have a fascination to those interested which seems to increase constantly. The expert, then, takes the model in whatever stage it may be, and through its use charts the lines along which the progress towards a more efficient path can be obtained. The motion model is to the expert a "thought detonator," or a stimulus to invention. On the other hand, to the beginner who is a learner, the motion model is a completed thing, a standard, and it should be in the most perfect state possible before being given to him. Through its use he can see what he is to do, learn about it through his eye, follow the wire with his fingers, and thus accustom his muscles to the activity that they are expected to perform. Moreover, he can, through the speed indications, follow the path at the desired speed, by counting, or by the use of specially designed timing devices that appeal to his eye, to his ear, or to both simultaneously. All of the sense teaching is thus closely correlated. A further correlation through books or through oral instructions concerning the significance of what he sees and touches, makes the instruction highly efficient.

This method of instruction may seem at first applicable to manual work only, but, as with its use the importance of decisions and their relation to the motions becomes more apparent, it will be seen that the complete field of use has by no means as yet been completely charted. So much for the motion model as a means of transferring experience, or of teaching.

We next turn to the motion model as a means for recording results. We have already discussed at some length the motion model as a record of a method of performing an activity. It can also serve as a record of the individual's, that is, the learner's response to the teaching. If at various stages of the individual's learning process his behavior be chronocyclegraphed and then motion modeled, and the results compared with the motion model, we have a very definite and visible standard of progress. If various individuals at the same stage of learning be thus handled, we have not only a record of their progress, but also a record of the value of the method being used. If proper test conditions be maintained, and other individuals be trained along a different method, and the various sets of motion models be then compared, we have a comparative record of results. It will be seen that this method of comparing results may be used even where the motion model has not in any way been used as a teacher. The results of any number of educational methods that manifest themselves in any form of behavior may be compared.

We have also a method that will record fatigue, and that, therefore, will make possible the determination of rest periods, their length compared to working periods, and also their distribution throughout the hours of the day.*

We have said many times that there is no waste in the world to-day that equals the waste in needless, ineffective and ill-directed motions and their resulting unnecessary fatigue. This means that there are no savings that can be made to-day that can compare with those made by eliminating useless motions, and transforming ineffective and ill-directed motions into properly di-

*See "Fatigue Study," Sturgis and Walton Company, New York City.

rected and efficient motions. "Motion Economy," "Savings" and "Waste Elimination" must be the watchwords of the day; savings not only in money, but in the mental and physical elements that produce the money and the durable satisfactions of life. in the mental and physical elements that produce the money. It is for you to conserve, to utilize and to increase this intelligence by training all people, and especially the coming generation, to become *thinkers in elements of motions.* The greatest wealth of the nation consists of the intelligence and skill of its people.